PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G02B 5/18, 26/08

A1

(11) International Publication Number: WO 91/02991

(43) International Publication Date: 7 March 1991 (07.03.91)

(21) International Application Number: PCT/GB90/01295

(22) International Filing Date: 16 August 1990 (16.08.90)

(30) Priority data:
8919220.7 24 August 1989 (24.08.89) GB

(71) Applicant *(for all designated States except US)*: BRITISH TELECOMMUNICATIONS PUBLIC LIMITED COMPANY [GB/GB]; 81 Newgate Street, London EC1A 7AJ (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : WELBOURN, Anthony, David [GB/GB]; 7 Fishbane Close, Ipswich, Suffolk IP3 0SE (GB).

(74) Agent: PRATT, David, Martin; British Telecommunications public limited company, Intellectual Property Unit, 151 Gower Street, London WC1E 6BA (GB).

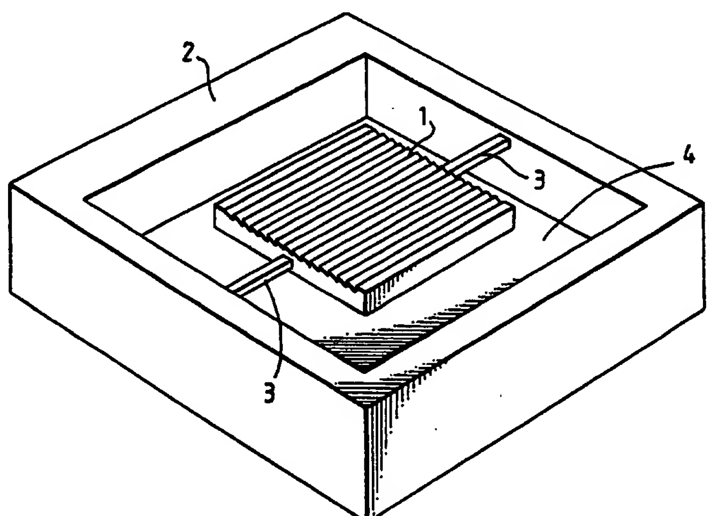
(81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent)*, DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.

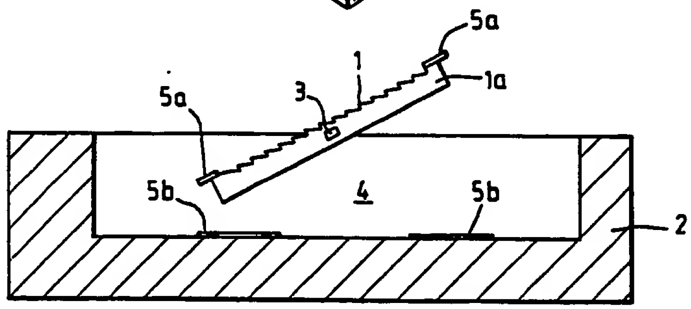
Published
With international search report.

(54) Title: DIFFRACTION GRATING ASSEMBLY

(57) Abstract

A diffraction grating assembly is constructed from a silicon substrate (2). The diffraction grating assembly comprises a support member (1a) formed in a cavity (4) etched in the substrate (2). A diffraction grating (1) is formed on the support member (1a), and means (3) are provided for supporting the support member on the substrate (2) for pivotal movement. Means (5a, 5b) are also provided for controlling the pivotal movement of the support member (1a).





* See back of page

DESIGNATIONS OF "DE"

Until further notice, any designation of "DE" in any international application whose international filing date is prior to October 3, 1990, shall have effect in the territory of the Federal Republic of Germany with the exception of the territory of the former German Democratic Republic.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MC	Monaco
AU	Australia	FI	Finland	MG	Madagascar
BB	Barbados	FR	France	ML	Mali
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Fasso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GR	Greece	NL	Netherlands
BJ	Benin	HU	Hungary	NO	Norway
BR	Brazil	IT	Italy	PL	Poland
CA	Canada	JP	Japan	RO	Romania
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	LI	Liechtenstein	SN	Senegal
CM	Cameroon	LK	Sri Lanka	SU	Soviet Union
DE	Germany	LU	Luxembourg	TD	Chad
DK	Denmark			TG	Togo
				US	United States of America

DIFFRACTION GRATING ASSEMBLY

This invention relates to an adjustable diffraction grating assembly, and to a method of making such an assembly.

Adjustable (tunable) diffraction gratings have many applications, for example where tunable optical filters or beam deflection are required. Particular uses of adjustable diffraction gratings are in long external cavity (LEC) lasers, wave division multiplexers (WDM), wavelength selectors for lasers and optical switching. In order to adjust (tune) such diffraction gratings, it is usual to use piezoelectric transducers to rotate the angle between the optical beam and the plane of the grating. Unfortunately, the use of piezoelectric transducers results in a very limited angular range through which a diffraction grating can be adjusted. This is because of the inherent limitations of piezoelectric material, in which the strain in the material is restricted to a relatively small value - otherwise the material would physically break.

It is known to form adjustable gratings monolithically by ruling grating lines into a torsion member formed by micromachining (EP A 0219 357). The ruling of the grating is a mechanical process which is not generally compatible with micromachining processes. Damage is introduced to the crystalline material, which will interfere with the process of cavity formation. Moreover, debris formed during the ruling of the grating lines will interfere with the microlithographic processes.

A primary aim of the invention is to provide an adjustable diffraction grating assembly that has greater adjustability than known assemblies

The present invention provides a diffraction grating assembly constructed from a monocrystalline substrate, the diffraction grating assembly comprising a support member formed in a cavity etched in the substrate, a diffraction grating formed on the support member by an anisotropic etching process, means for supporting the support member on the substrate for pivotal movement, and means for controlling the pivotal movement of the support member.

The anisotropic etching process reveals angled crystal planes, and ensures extremely accurate alignment of the grating lines.

Advantageously, the substrate is a silicon substrate, preferably a {hhl} silicon substrate, where h and l are the Miller indices of the plane of the substrate. Conveniently, the substrate is a (hhl) silicon substrate, whereby the faces of the grating are the (111) and $(11\bar{1})$ planes, the grating lines lying in the direction $[1\bar{1}0]$.

In a preferred embodiment, torsion bars constitute the means for supporting the support member on the substrate, the torsion bars being integral with the substrate and the support member. Advantageously, the torsion bars lie in the direction $[1\bar{1}0]$. The anisotropic etching process forms the grating so that the whole device is formed by standard chemical micromachining processes. This gives the added benefit of improved grating efficiency, because the grating surfaces are smoother, and improved orientation alignment between the grating and the torsion members.

Conveniently, electrodes are formed on the support member and within the cavity, the electrodes constituting the means for controlling the pivotal movement of the support member.

The invention also provides a diffraction grating assembly as defined above in combination with at least one micromachined device, said at least one micromachined device being formed on the substrate.

The invention also provides a method of constructing a diffraction grating assembly, the method comprising the steps of forming a support member in a cavity etched in a monocrystalline substrate, the support member being attached to the substrate by a pair of aligned torsion bars, forming a diffraction grating on the support member by an anisotropic etching process, and providing electrodes on the support member and within the cavity, whereby the support member can be controllably pivoted about the torsion bars.

The cavity may be formed in the substrate by an anisotropic etching process using, for example, ethylene diamine pyrocatechol and water (EDP) or KOH. Conveniently, the etching is carried out from that side of the substrate adjacent to the support member. Alternatively, the etching is carried out from that side of the substrate remote from the support member. In the latter case, the method further comprises the step of forming a base to the cavity by bonding a further silicon or glass substrate to that side of the first-mentioned substrate remote from the support member.

The further substrate may incorporate at least one built-in electrode, and at least one further electrode may be formed on that surface of the support member adjacent to the further substrate. Advantageously, the electrodes may be formed by evaporation of, for example, aluminium. Alternatively, the electrodes are formed by evaporation of a ferromagnetic material.

In a preferred embodiment, the or each electrode within the cavity is formed by:-

(a) etching a via in the substrate from that side of the substrate remote from the support member;

(b) forming a thin insulating layer, for example by oxidation or deposition; and

(c) depositing metal in the via.

In this case, the monocrystalline substrate includes a buried p^+ layer, and the etching of the or each via is carried out in two stages, a first of which uses an anisotropic etchant which terminates at the p^+ buried layer, and the second of which uses an isotropic or selective p^+ etchant.

Preferably, the anisotropic etching process used to form the diffraction grating utilises KOH or EDP as the etchant.

A laser usually has an internal cavity with reflecting walls at opposite ends thereof. In use, light beams bounce backwards and forwards between the reflecting walls, the output of the laser being a balance between the percentage of light which leaks out through one of the reflecting walls and the number of times a light beam is reflected. The output of the laser is constituted by a plurality of discrete frequency components (modes) covering a relatively broad frequency range.

In order to use a laser at a high operating speed, it is essential for it to have widely-spaced modes, each having a narrow linewidth. A laser having a large internal cavity results in modes having narrow linewidths. Unfortunately, however, the large internal cavity also results in the modes being closely spaced. One way of achieving a large cavity which results in modes having particularly narrow linewidths is to form an external cavity. Such a long external cavity (LEC) laser is formed by coating one end wall of the internal cavity of a laser with an anti-reflection coating (so that almost all the light hitting that end will escape therethrough),

and by placing a mirror a predetermined distance away. The mirror and the other end wall of the laser thus define the cavity (known as an external cavity) of the laser. The disadvantage of an LEC laser, apart from the closely-spaced modes, is that the accuracy with which the mirror must be placed cannot, in practice, be achieved.

It is known to replace the mirror of an LEC laser with a diffraction grating, the diffraction grating being suitably angled to diffract light back to the laser. This superimposes grating characteristics on top of the laser characteristics, which leads to widely-spaced modes. Unfortunately, because the grating is mounted on piezoelectric transducers, the arrangement is expensive because it is time-consuming to assemble and align correctly.

The invention further provides a long external cavity laser comprising a laser diode and a diffraction grating assembly, the diffraction grating assembly being as defined above, and the laser diode being mounted in a cavity etched in the substrate. The laser may further comprise beam shaping optics positioned on the substrate between the laser diode and the diffraction grating assembly.

The invention will now be described in greater detail, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic perspective view of of a diffraction grating assembly constructed in accordance with the invention;

Figure 2 is a schematic side elevation of the assembly of Figure 1;

Figure 3 is a diagram illustrating the process for forming the assembly of Figures 1 and 2;

Figure 4 is a diagram illustrating the orientation of the grating assembly;

Figure 5 is a diagram illustrating the relationship between grating orientation and the angles of the grating faces of the grating of the assembly;

Figures 6 to 8 are diagrams illustrating a method of forming electrodes for controlling the adjustability of the grating assembly;

Figure 9 is a schematic perspective view of an LEC laser incorporating the grating assembly; and

Figure 10 is a schematic side elevation of the LEC laser.

Referring to the drawings, Figures 1 and 2 show a monolithic adjustable diffraction grating assembly comprising a diffraction grating 1 formed in a (hhl) silicon substrate. Figure 4 shows schematically the orientation of the grating 1 on the substrate 2, the grating lines lying in the direction $[1\bar{1}0]$ of the (hhl) substrate, h and l being the Miller indices of the plane of the substrate. In this case, for convenience of analysis, the usual notation of a (100) substrate is replaced by the symmetrically - related plane (001), so that the grating 1 is orientated along the $[1\bar{1}0]$ direction.

The diffraction grating 1 is formed by etching (in a manner described below) the substrate 2. This etching process is such as to form a pair of aligned bars 3 which define a torsion paddle. The bars 3 are integral with the grating 1 and the substrate 2, and are positioned centrally so as to define a central axis about which the grating can pivot. This etching process also defines a cavity 4 beneath the grating 1, this cavity permitting the grating to pivot so as to be suitably angled. Pairs of electrodes 5a and 5b are fixed to the grating 1, and to the base of the cavity 4 respectively, so that the angular position of the grating can be controlled electrostatically.

The grating 1 of the assembly shown in Figures 1 and 2 is made in a manner described below with reference to Figure 3. A low doped (either n or p) epilayer 6 is formed on the substrate 2 which is doped p^+ (using boron). The grating 1 is then formed by an anisotropic etch, using KOH or EDP, through a suitably-defined masking layer of silicon oxide or silicon nitride. With this type of etchant, a blazed grating 1 results in which the blaze angle is related to the crystal structure. Where the substrate 2 is a (112) substrate, the grating has a vertical alignment edge. Alternatively, if (100) silicon were used, a symmetrical V-grooved grating would result. In either case, the etch stops along the crystal planes (111) and $(11\bar{1})$ to define the grating lines (as shown in Fig 5).

The table below shows the relationship between the blaze angles a and b of gratings for a variety of low-index substrates:-

(hhl)	Angle a	Angle b	Angle C
(001)	54.7°	54.7°	70.5°
(115)	38.9°	70.5°	70.5°
(113)	29.5°	80.0°	70.5°
(112)	19.5°	90°	70.5°
(221)	15.8°	54.7°	109.5°
(110)	35.3°	35.3°	109.5°

Boron is then diffused into the region 1a surrounding the grating 1 to form a p^+ region which forms a support member for the grating . At the same time, boron is diffused into the regions (not shown in Figure 3) which are to form the torsion bars 3. These regions thus form p^+ regions.

The grating 1 is then coated with a metal such as aluminium, chromium, gold or silver, by evaporation. A passivating dielectric coating may also be required to protect the metal during subsequent processing. The grating pitch is between 0.5 and 1.5 μm for optical transmission at 1.3 or 1.55 μm, these being the standard transmission windows for optical fibre communications at which silicon is transparent.

Using an anisotropic etchant such as EDP, the epilayer 6 surrounding the region 1a is etched away to form the cavity 4, the torsion bars 3 and the "floating" grating 1, the cavity being defined by patterning a window in a surface masking layer (not shown). The p^+ regions 1a and 3 and the heavily-doped substrate 2 are not affected by this etching step.

The electrodes 5a can be plated on top of the grating 1, after a dielectric insulation layer (not shown) has been deposited and before the cavity 4 is etched out. The heavily-doped substrate 2 forming the base of the cavity 4 could itself form the electrodes 5b. Alternatively, a conformal metallic coating (for example CVD tungsten) or silicide could be used for the electrodes 5b, thereby reducing the contact resistance of the electrodes.

Figures 6 to 8 illustrate an alternative method of forming the electrodes 5b. In this method, a heavily-boron-doped p^+ region 2b is formed at the surface of a low-doped substrate 2a by diffusion or ion implantation. A low-doped (n or p) epilayer 6 is formed on the (p) substrate 2, so the region 2b becomes a buried layer. A grating 1 is then formed within a cavity 4 in the manner described above with reference to Fig. 3, the cavity being defined by patterning a window in a surface masking layer (not shown). The mask used to form the grating 1 (a nitride mask) is retained in place on top of

the grating, and an oxide layer 7 is thermally grown (see Figure 7). The oxide layer 7 has a thickness in the range of from 0.1 to 1.0 μm, the upper limit being set by the requirement that the oxide layer should not be thick enough to bend the grating 1. The mask protects the grating 1 during this thermal oxidation step. Two vias 8 are then formed in the substrate 2a by an anisotropic etching process from the back of the substrate. This anisotropic etching process terminates at the P^+ buried layer 2b. This stage of the process is shown in Figure 7.

The etching process is then continued using an isotropic etchant (such as a mixture of HF, HNO_3 and acetic acid) or a selective P^+ etchant (such as Dash etch). This etching process terminates at the oxide layer 7. A thin insulating layer 9 is then formed on the exposed silicon surfaces of the vias 8, for example by oxidation. Electrodes 5b are then formed by a standard metal deposition and patterning method.

In an alternative method of forming the grating 1, the cavity 4 could be etched out from beneath, in which case a further silicon or glass wafer would be bonded to the substrate 2 to form the base of the cavity 4. This additional wafer would have the electrodes 5b built-in. The advantage of this alternative method is that the electrodes 5a could be formed on the underneath surface of the grating 1, for example by evaporation of aluminium. Alternatively, the electrodes 5a and 5b could be formed by depositing a ferromagnetic material, in which case electromagnetic forces would be used to angle the grating 1 instead of electrostatic forces.

Instead of using ferromagnetic material, solenoids could be incorporated into the substrate 2, so that ferromagnetic forces could again be used to control the angle of the grating 1.

Figures 9 and 10 show a LEC laser incorporating a monolithic adjustable diffraction grating assembly constructed in accordance with the invention. The LEC laser includes a laser diode 10 which is mounted in a laser cavity 11 etched in the substrate 2 in which diffraction grating assembly is formed. One end wall 10a of the laser diode 10 is coated with anti-reflection material (not shown) so that light readily passes therethrough. The axis of the torsion bars 3 is arranged to lie at right-angles to the beam of light from the laser diode 10, so that the grating 1 can be suitably angled to diffract light from the laser diode back to the laser diode, thereby defining an LEC laser.

Beam shaping optics 12 (see Fig.10) are provided for accurately directing the output of the laser diode 10 to the grating 1. The beam shaping optics 12 could be a Fresnel lens etched into a pillar on the substrate 2, thereby providing lateral beam shaping but no vertical control. Alternatively, the output of the laser diode 10 could be coupled directly into a waveguiding slab to give vertical confinement. In this case, a Fresnel lens would be used to provide lateral beam shaping, and both the waveguide and the lens would be produced monolithically. It would also be possible to etch a slot in the substrate, the slot providing an accurate mount for an external lens component.

As an alternative to defining unetched regions by p^+ layers prior to selective etching in EDP or KOH, it would be possible to define these regions by p/n junctions and to use an electrochemical etching technique, in which the p regions are etched and the n regions are not. It would also be possible to form these structures in silicon-on-insulator (SOI), where the cavity 4 would be formed by removing the insulator using any suitable etchant, such as hydrofluoric acid where the insulator is oxide.

CLAIMS

1. A diffraction grating assembly constructed from a monocrystalline substrate, the diffraction grating assembly comprising a support member formed in a cavity etched in the substrate, a diffraction grating formed on the support member by an anisotropic etching process, means for supporting the support member on the substrate for pivotal movement, and means for controlling the pivotal movement of the support member.

2. An assembly as claimed in claim 1, wherein the substrate is a silicon substrate.

3. An assembly as claimed in claim 2, wherein the substrate is a {hhl} silicon substrate, where h and l are the Miller indices of the plane of the substrate.

4. An assembly as claimed in Claim 3 wherein the substrate is a (hhl) silicon substrate, whereby the faces of the grating are the (111) and $(11\bar{1})$ planes, the grating lines lying in the direction $[1\bar{1}0]$

5. An assembly as claimed in any one of claims 1 to 4, wherein torsion bars constitute the means for supporting the support member on the substrate, the torsion bars being integral with the substrate and the support member.

6. An assembly as claimed in claim 5 when appendent to claim 4, wherein the torsion bars lie in the direction $[1\bar{1}0]$.

7. An assembly as claimed in any one of claims 1 to 6, wherein electrodes are formed on the support member and within the cavity, the electrodes constituting the means for controlling the pivotal movement of the support member.

8. A diffraction grating assembly substantially as hereinbefore described with reference to, and as illustrated by, the accompanying drawings.

9. A diffraction grating assembly as claimed in any one of claims 1 to 8, in combination with at least one micromachined element, said at least one micromachined element being formed monolithically on the substrate.

10. A long external cavity laser comprising a laser diode and a diffraction grating assembly, the diffraction grating assembly being as claimed in any one of claims 1 to 8, and the laser diode being mounted in a cavity etched in the substrate.

11. A laser as claimed in claim 10, further comprising beam shaping optics positioned on the substrate between the laser diode and the diffraction grating assembly.

12. A long external cavity laser substantially as hereinbefore described with reference to, and as illustrated by, Figures 9 and 10 of the accompanying drawings.

13. A method of constructing a diffraction grating assembly, the method comprising the steps of forming a support member in a cavity etched in a monocrystalline substrate, the support member being attached to the

substrate by a pair of aligned torsion bars, forming a diffraction grating on the support member by an anisotropic etching process, and providing electrodes on the support member and within the cavity, whereby the support member can be controllably pivoted about the torsion bars.

14. A method as claimed in claim 13, wherein the cavity is formed in the substrate by an anisotropic etching process.

15. A method as claimed in claim 14, wherein the etching is carried out from that side of the substrate adjacent to the support member.

16. A method as claimed in claim 14, wherein the etching is carried out from that side of the substrate remote from the support member.

17. A method as claimed in claim 16, further comprising the step of forming a base to the cavity by bonding a further silicon or glass substrate to that side of the first-mentioned substrate remote from the support member.

18. A method as claimed in claim 17, wherein the further substrate incorporates at least one built-in electrode.

19. A method as claimed in claim 18, wherein at least one further electrode is formed on that surface of the support member adjacent to the further substrate.

20. A method as claimed in claim 19, wherein said electrodes are formed by evaporation of, for example, aluminium.

21. A method as claimed in claim 18, wherein said electrodes are formed by evaporation of a ferromagnetic material.

22. A method as claimed in 15, wherein the or each electrode within the cavity is formed by:-

(a) etching a via in the substrate from that side of the substrate remote from the support member;

(b) forming a thin insulating layer, for example by oxidation or deposition; and

(c) depositing metal in the via.

23. A method as claimed in claim 22, wherein the monocrystalline substrate includes a buried p^+ layer, and the etching of the or each via is carried out in two stages, a first of which uses an anisotropic etchant which terminates at the p^+ buried layer, and the second of which uses an isotropic or selective p^+ etchant.

24. A method as claimed in any one of claims 13 to 23, wherein the or each anisotropic etching process utilises KOH or EDP as the etchant.

25. A method of constructing a diffraction grating assembly substantially as hereinbefore described with reference to Figure 3 or Figures 6 to 8 of the accompanying drawings.

Fig.1

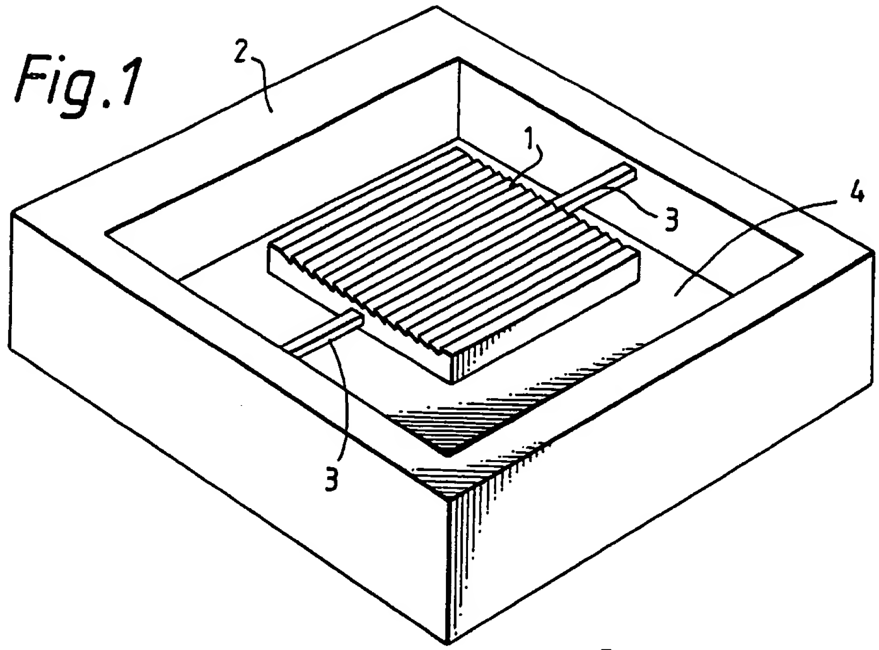


Fig.2

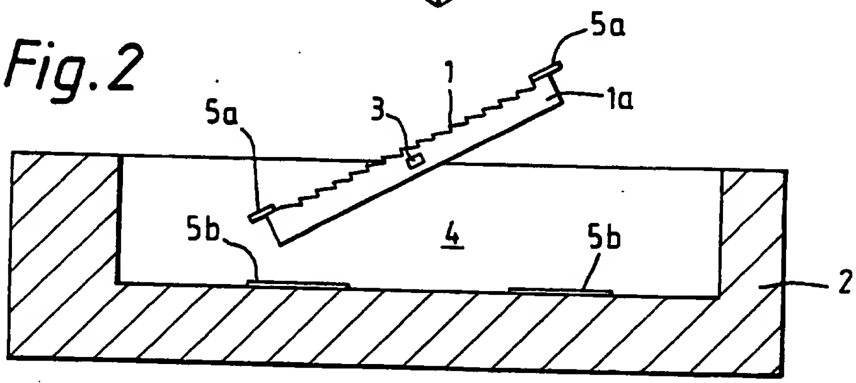


Fig.3

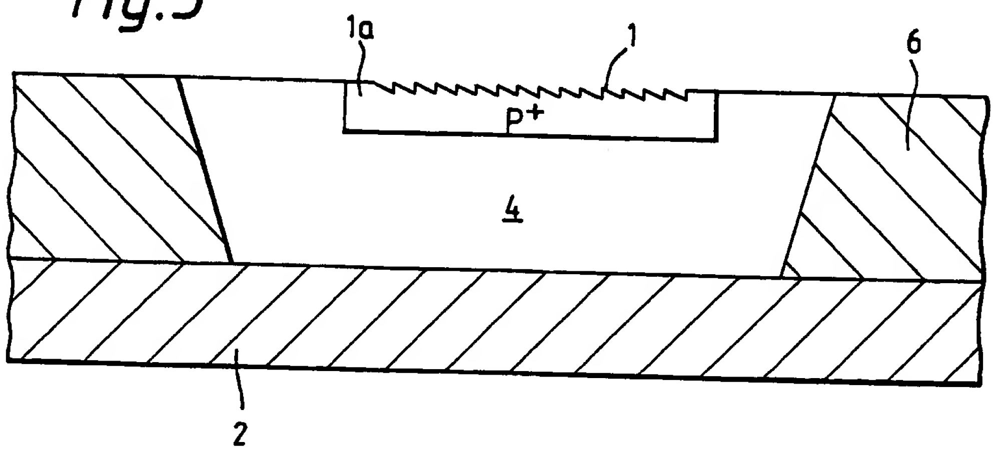


Fig.4

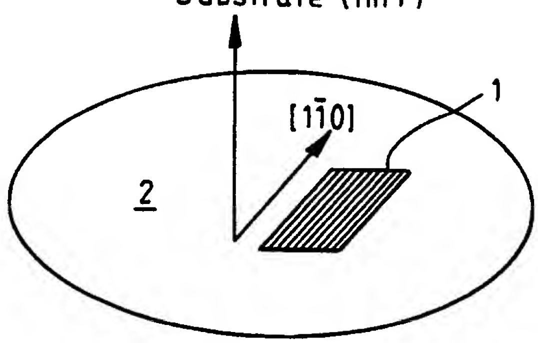

Substrate (hh1)
[1$\bar{1}$0]
1
2

Fig.5

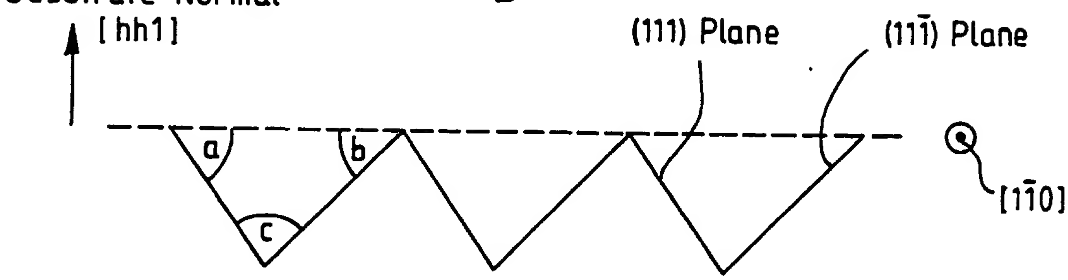

Substrate Normal
[hh1]
(111) Plane
(11$\bar{1}$) Plane
a
b
c
[1$\bar{1}$0]

Fig.6

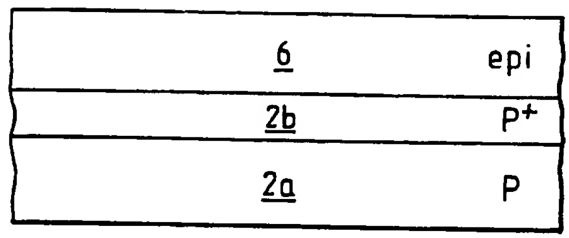


Fig.7

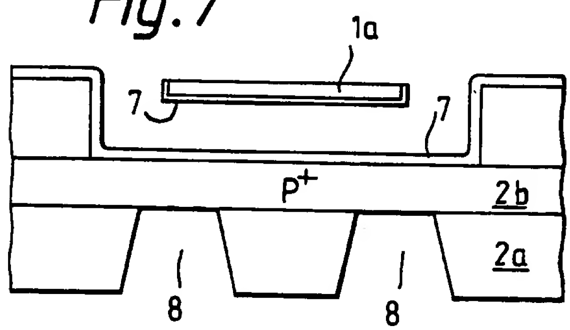
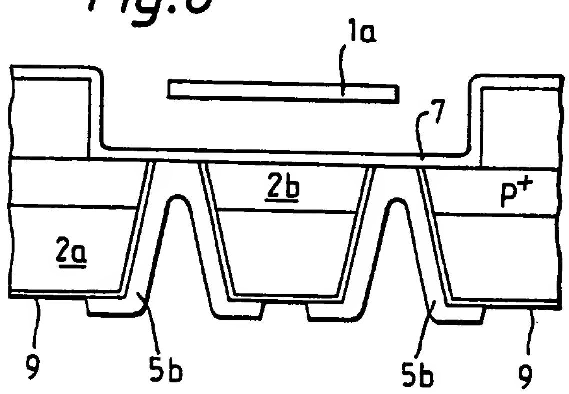


Fig.8



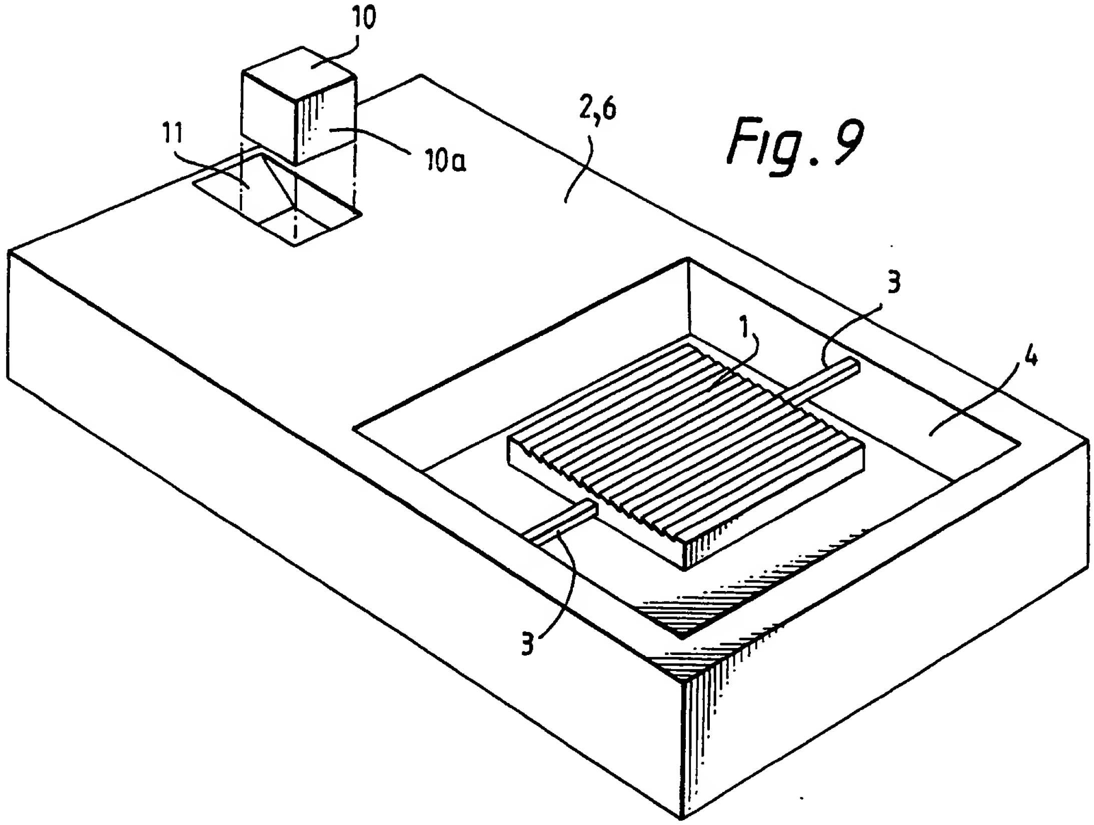


Fig. 9

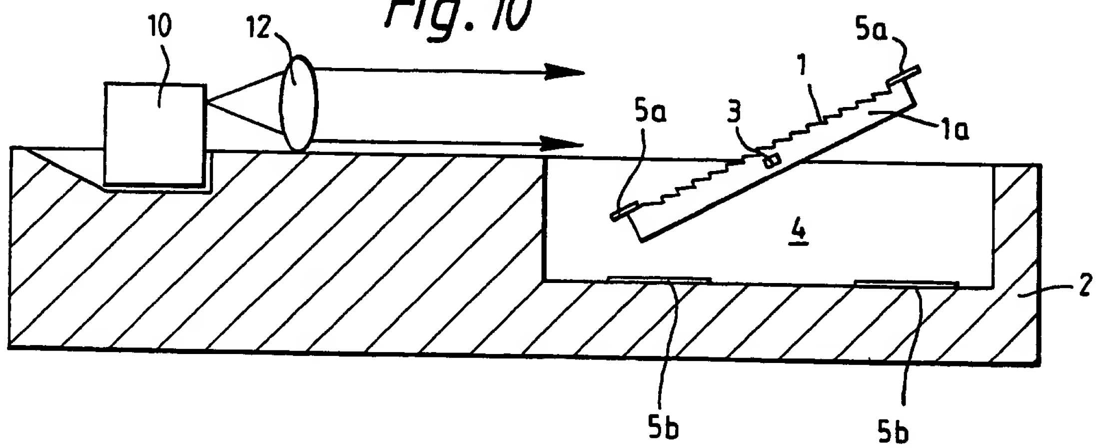


Fig. 10

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/01295

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^5: G 02 B 5/18, G 02 B 26/08

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^5	G 02 B, H 01 S, G 09 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y	EP, A, 0219357 (BRITISH TELECOMMUNICATIONS p.l.c.) 22 April 1987 see column 1, line 48 - column 2, line 8; column 2, line 41 - column 3, line 25; column 3, lines 37-47; figures 1,2	1-3,5,7-9 13,14,24
A	(cited in the application)	4,6,10-12, 15-23,25
Y	EP, A, 0059304 (NIPPON TELEGRAPH AND TELEPHONE p.l.c.) 8 September 1982 see page 13, lines 14-17; claim 1	1-3,5,7-9, 13,14,24
A		4
A	Patent Abstracts of Japan, volume 12, no. 385 (E-668)(3232), 14 October 1988, & JP, A, 63129686 (MATSUSHITA ELECTRIC IND. CO. LTD.) 2 June 1988 see the whole abstract	1,10-12

./.

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
2nd November 1990	20 NOV 1990
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	Mme N. KUIPER

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	DE, A, 3732625 (SIEMENS A.G.) 6 April 1989 see column 3, lines 9-20; figure 1 --	1,10-12
A	US, A, 4662746 (HORNBECK) 5 May 1987 see column 11, lines 22-28; claims 17,18; figures 8A,8B ----	1,13

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9001295

SA 39309

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 14/11/90
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A- 0219357	22-04-87	EP-A- 0226296	24-06-87
		EP-A- 0223414	27-05-87
		EP-A,B 0219356	22-04-87
		EP-A- 0219358	22-04-87
		EP-A,B 0219359	22-04-87
		WO-A- 8702474	23-04-87
		WO-A- 8702518	23-04-87
		WO-A- 8702472	23-04-87
		WO-A- 8702476	23-04-87
		WO-A- 8702475	23-04-87
		WO-A- 8702470	23-04-87
		JP-T- 63501600	16-06-88
		JP-T- 63501382	26-05-88
		JP-T- 63501383	26-05-88
		JP-T- 63501384	26-05-88
		JP-T- 63501393	26-05-88
		JP-T- 63501385	26-05-88
		US-A- 4867532	19-09-89
		US-A- 4854658	08-08-89
		US-A- 4802727	07-02-89
		US-A- 4825262	25-04-89
		US-A- 4871244	03-10-89
		US-A- 4846930	11-07-89
		US-A- 4896936	30-01-90
		CA-A- 1271552	10-07-90
EP-A- 0059304	08-09-82	JP-A- 55133004	16-10-80
		JP-A,B,C55134806	21-10-80
		JP-A- 55015133	02-02-80
		CA-A- 1113752	08-12-81
		EP-A,B 0007108	23-01-80
		US-A- 4330175	18-05-82
		US-A- 4405405	20-09-83
DE-A- 3732625	06-04-89	None	
US-A- 4662746	05-05-87	None	

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82